Analysis of Metrics Utilized in U.S. Joint Experimentation of Future C2 Concepts

RADM Gary Wheatley USN (Ret.)
Evidence Based Research, Inc.
1595 Spring Hill Road Suite 250
Vienna, Virginia USA 22182-2216
[1] 703-893-6800
wheatley@ebrinc.com

Key Words
C2, Metrics, Experimentation

Abstract

The U.S. Joint Forces Command has been charged to lead the transformation of the U.S. Armed Forces through development and experimentation of new command and control concepts. In particular the Knowledge-C2 Working Group of the Concepts Division has focused on four related concepts:

- *Adaptive Joint Command and Control (AJC2)*

- *Common Relevant Operational Picture (CROP), and the Collaborative Information Environment (CIE)*

- *Joint Interactive Planning (JIP)*

- *Multinational Operations (MNOPS)*

This paper discusses these Knowledge-C2 concepts and related experiments in the U.S. JFCOM experimental campaign. It then reports on the Unified Vision 2001 Experiment (UV01) results showing how the HEAT metrics were used to develop analyses baselines and quantitative results. Finally it discusses the future of the experimental campaign and events.

1   Introduction

As the U.S. Joint Forces Command pursues its mission of transforming the U.S. Armed Forces, it has embarked on an experimental campaign that is designed to test new and innovative concepts for transformation. The current integrating, or over-aching concept is Rapid Decisive Operations (RDO), a concept to achieve rapid victory by attacking the coherence of an enemy's ability to fight. It involves the synchronous application of the full range of national capabilities in timely and direct Effects-Based Operations (EBO). It employs asymmetric advantages in the knowledge, precision, and mobility of the Joint Force against an adversary's critical functions to create maximum shock. Supporting RDO and EBO are several Knowledge and Command and Control (K-C2) concepts vital to RDO success. These K-C2 concepts include:

- Adaptive Joint Command and Control (AJC2)

- Common Relevant Operational Picture (CROP), and the Collaborative Information Environment (CIE)

- Joint Interactive Planning (JIP)

- Multinational Operations (MNOPS)

Figure 1 shows how these and other related concepts support RDO in the context of a Small Scale Contingency (SSC).

Report Documentation Page		Form Approved OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE **SEP 2002**	2. REPORT TYPE	3. DATES COVERED **00-00-2002 to 00-00-2002**
4. TITLE AND SUBTITLE **Analysis of Metrics Utlized in U.S. Joint Experimentation of Future C2 Concepts**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Evidence Based Research Inc,1595 Spring Hill Road Suite 250,Vienna,VA,22182-2216**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES **The original document contains color images.**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES **16**	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**			

Standard Form 298 (Rev. 8-98)
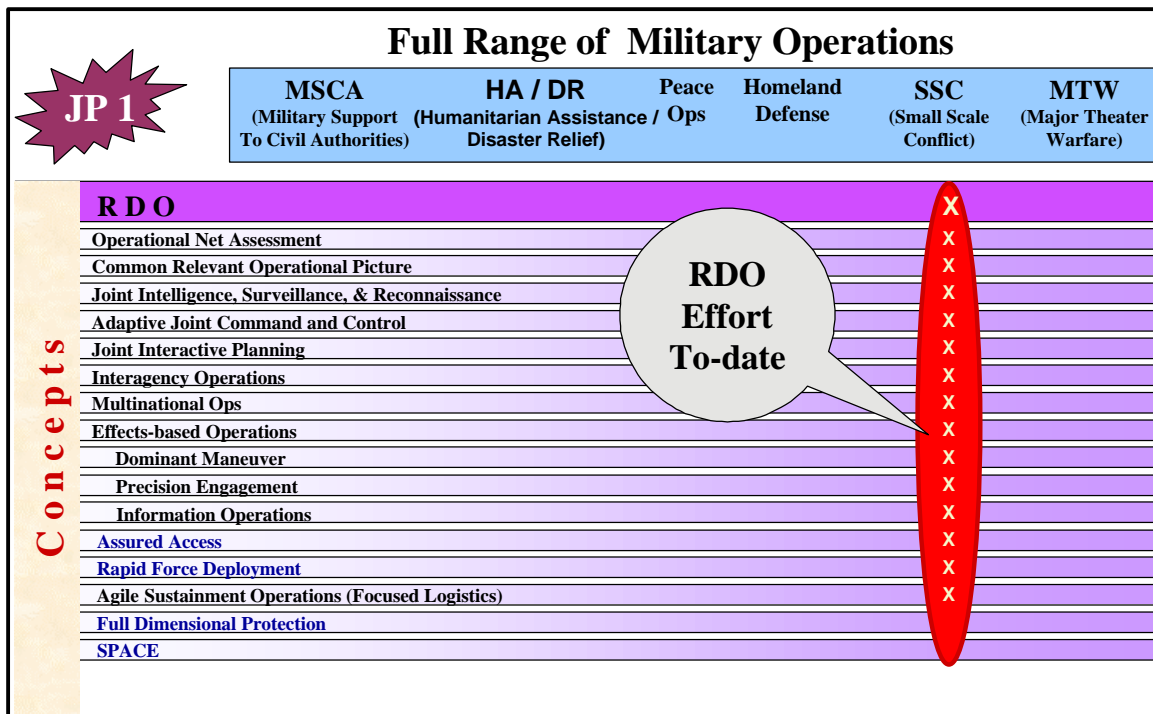Prescribed by ANSI Std Z39-18

Figure 1: A View of the RDO Concept Family

This paper focuses on selected Knowledge-C2 concepts and related experiments in the U.S. JFCOM experimental campaign. It then reports on the UV 01 experiment assessment results. In particular it discusses the Headquarters Effectiveness Assessment Tool (HEAT) metrics used to develop analyses baselines and quantitative results. Finally it discusses the future of the experimental campaign and related events.

2 The Knowledge-Command and Control Concepts

2.1 Adaptive Joint Command and Control (AJC2)

RDO require more responsive and coherent advanced planning and quicker use of capabilities than can be accomplished by ad hoc stand up of a JTF headquarters.
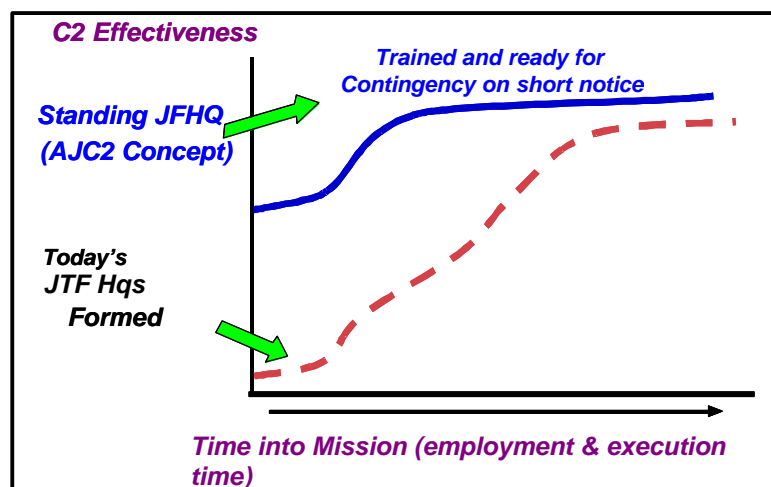

Figure 2: Improving JTF Readiness and Responsiveness

Currently, when a Joint Task Force (JTF) is established, the crisis often has already evolved or is close to involving combat operations or overt hostile action by the adversary. As crisis management passes from the CINC to a JTF Commander, the coherency of plans and in-process actions may be lost. The new JTF commander must establish situational awareness, create a team, and establish processes that have not been practiced with the new team. At the most critical time of a crisis, when small actions can make large differences in the outcome, the C2 is in danger of being the most dysfunctional. This is illustrated by the bottom line in Figure 2.

Taking advantage of improvements in information technology, RDO AJC2 will use networks touching every part of the force and touching those that will provide information and direction to the force. These networks will be used before, during and after the crisis for training, planning, and communication. Practiced collaboration, habitual relationships, and sharing of situational understanding will enable greater coherence of C2 and more rapid and effective execution. The foundation for improved C2 will be a standing joint force command and control element in each CINC's headquarters (the top line in Figure 2). The C2 element will have the equipment, training and authority to become a backbone around which a JTF Commander's staff, when stood up, will operate. Rapidly deployable, and when augmented, this C2 element will be capable of operating alone for a small JTF contingency, or operating as part of a standing service operational headquarters designed as a JTF or the CINC's staff, depending on the size, scope and the expected duration of crisis response operations. This C2 element develops an Operational Net Assessment (ONA), which is an in-depth, systems of systems analysis of a region or potential adversary to identify and develop plans for a CINC priority set of selected missions. This process is shown in Figure 3.

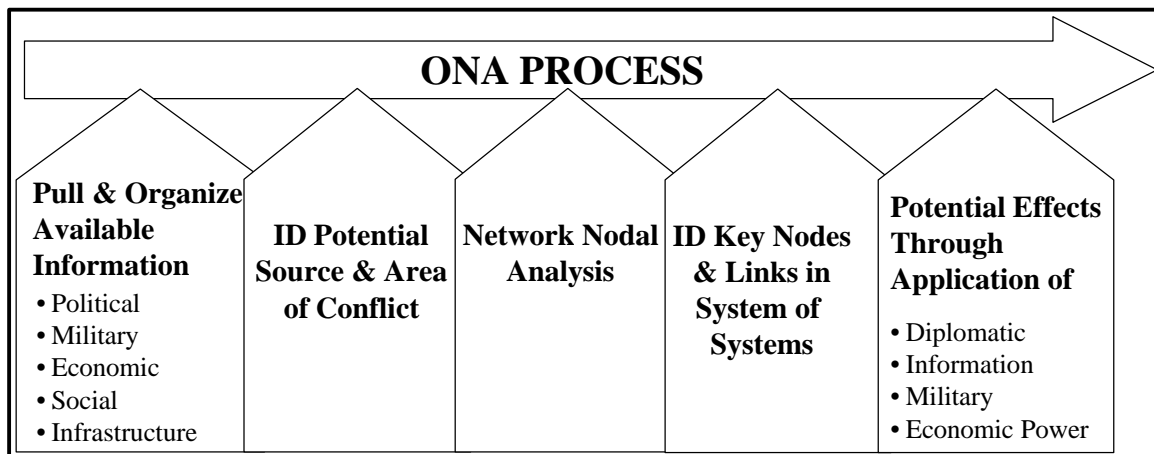| ONA PROCESS				
Pull & Organize Available Information • Political • Military • Economic • Social • Infrastructure	**ID Potential Source & Area of Conflict**	**Network Nodal Analysis**	**ID Key Nodes & Links in System of Systems**	**Potential Effects Through Application of** • Diplomatic • Information • Military • Economic Power

Figure 3: ONA Process Elements

The coordinated application of national power is enabled by a refined interagency collaboration process that allows all partners to "inform and be informed by" the others. The C2 element works closely with the experimental interagency coordination cell (now designated as JX) on the CINC's staff. The value of reducing or eliminating the ad hoc nature of IAC response and political/military coordination will be a key element in successful RDO. Understanding that future operations will be conducted in a multinational environment, we will work with our partners to take advantage of the key assets, legitimacy, and political support they provide. The challenges of policy, dissimilar training, equipment, technology, doctrine, and language will be mitigated by peacetime engagement, training, and shared tools for planning.

In its day-to-day role the SJFHQ will develop the ONA and will have practiced those processes critical to crisis management and JTF execution. They will be prepared to respond with full situational awareness, practiced teamwork, and embedded collaborative processes and tools.

This should provide several key advantages:

• Possesses pre-crisis knowledge and understanding

- Becomes a high performance, well-trained team that understands the C2 processes and tools

- Takes advantage of habitual relationships formed with CINC's staff, subordinate commanders, and interagency and multinational participants. The SJFHQ would maintain important "reach-back" links to U.S. strategic planning and intelligence organizations, non-DoD agencies

- Conduct distributed C2 through multiple collaborative networks.

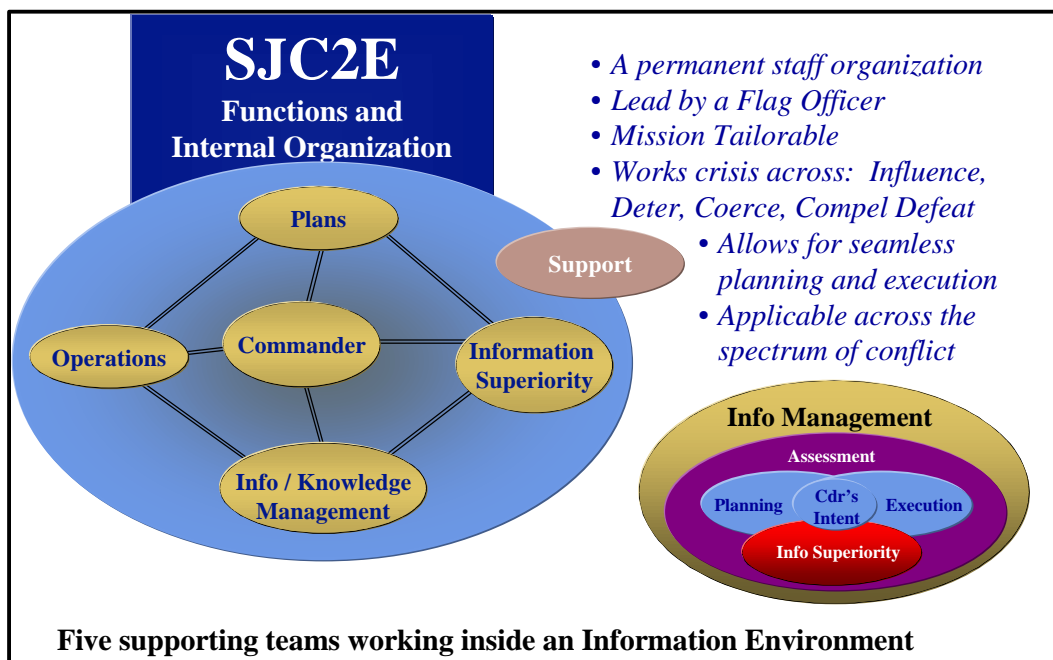Figure 4 illustrates one way the organization could function.

Figure 4: Alternative Command Arrangements for the JFHQ

The AJC2 concept is *adaptive* in its actual composition and in the ways that the SJFHQ could transition from a peacetime posture to actual JTF operations. In the Millennium Challenge 2002 major experiment (MC 02) for example, the CINC designates a Service component headquarters as the JTF headquarters. This staff organizes itself as a JTF command staff around the knowledge based structure utilized by the SJFHQ.

2.2   Common Relevant Operational Picture (CROP)

The CROP is a "virtual information warehouse" that links to all the available information that the warfighters require. From this virtual warehouse, decision makers will tailor information displays that are relevant to their individual needs. The tailored displays generated from the common virtual warehouse will provide enhanced and shared Battlespace awareness at all levels. This is illustrated in Figure 5.
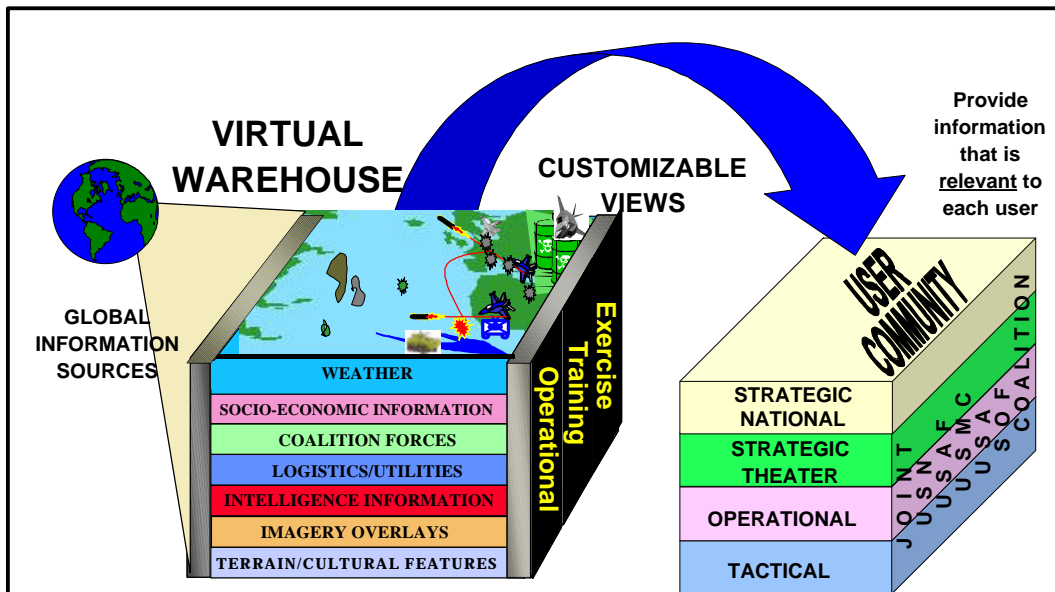
Figure 5: The Common Relevant Operational Picture

The CROP concept focuses on the ability to access the virtual data/information warehouse enabling a presentation of timely, accurate, and relevant information that can be tailored to meet the requirements of the Joint Force Commander and every organization and individual operating in a joint environment. It includes and mutually supports non-DoD organizations, allied/coalition forces, and the existing common tactical pictures of the Services. The CROP's enabler, the Global Information Grid (GIG), interconnects associated processes and personnel for collecting, processing, storing, disseminating, and managing information on demand to warfighters, policy makers, and support personnel.

CROP is a key enabler to Adaptive Joint Command and Control, enhanced battle space awareness, and Joint Interactive Planning (JIP). The CROP is a functional concept that proposes the presentation of timely, fused, accurate, assured, and relevant information that can be tailored to meet the requirements of the joint force commander and the joint force. The goal is to find and present only that best set of relevant information the warfighting commander needs to make good decisions and to act. This is critical because a rapid decisive operation will be won through rapid, decisive actions.

The CROP concept is sufficiently robust and adaptable to accommodate the full range of exchange of information with non-DoD organizations (including governmental, international, and private) and coalition forces. It embraces and mutually supports the existing common tactical picture of the Services. The resultant presentation of information will be rapidly accessible by all approved users and will support the full range of military operations. Simply put, the CROP concept will attempt to define what information needs to be collected, how it should be processed (analysis and fusion), how it will be disseminated, and how it will be presented in the future.

2.3   Joint Interactive Planning (JIP)

The JIP concept embodies the notion of the use of information superiority to rapidly reach decision superiority. Previously, planning and execution have traditionally progressed in a distinct and sequential hierarchy. The JIP concept addresses a parallel planning process within a Collaborative Information Environment (CIE—note that the CROP and the JIP are both parts of the CIE). This environment utilizes distributed collaboration tools and virtual collaboration to facilitate simultaneity among CINC headquarters, Standing Joint Force Headquarters (SJFHQ), Joint Force staffs, the Service components, allies, and other organizations that are separated by time, organizational boundaries, and geography. The result is a common shared awareness, unity of effort, and better understanding of the commander's intent. The JIP concept leverages the latest technology advances in information and decision support systems and processes such as intelligent agents, which search secure, and open source databases to find information needed to support

planning and execution. Support systems will extract, fuse, and translate the data to make it useful for decisionmakers. This is illustrated in Figure 6.
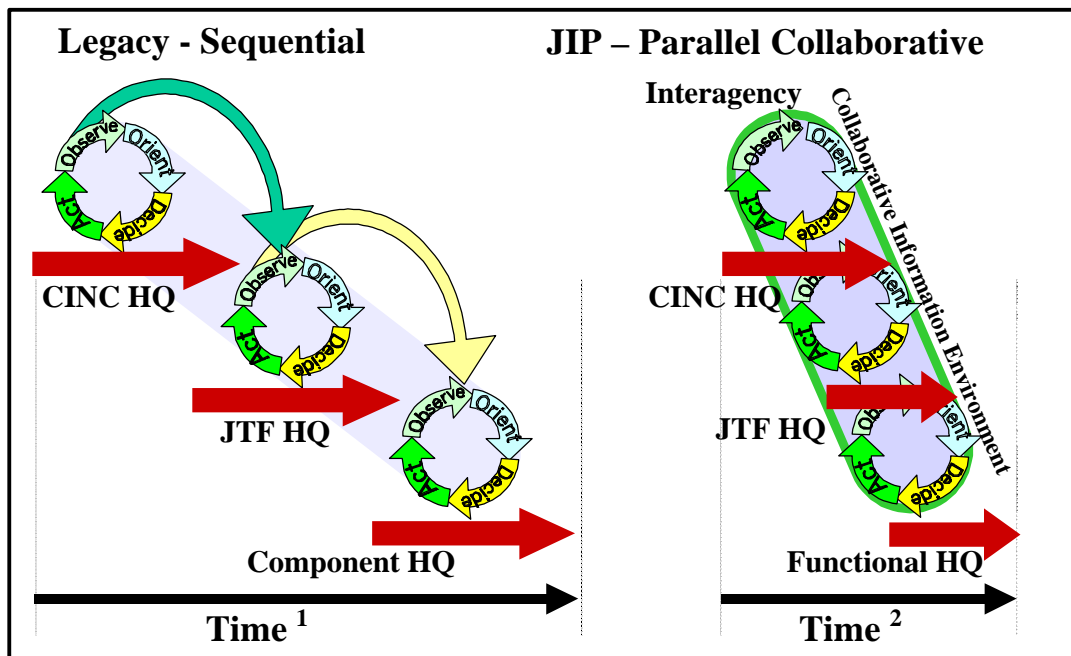

Figure 6: The Joint Interactive Planning Concept

2.4 Multinational Operations (MNOPS)

Multinational Operations is not a unique concept in itself—rather it is the purposeful inclusion of multinational and coalition considerations and requirements in all the other supporting concepts. To facilitate MNOPS we have commenced a series of multinational Limited Objective Experiments (LOE) as depicted in Figure 7. Note that MNOPS will be included in the major experiment, Olympic Challenge 2004 (OC 04).
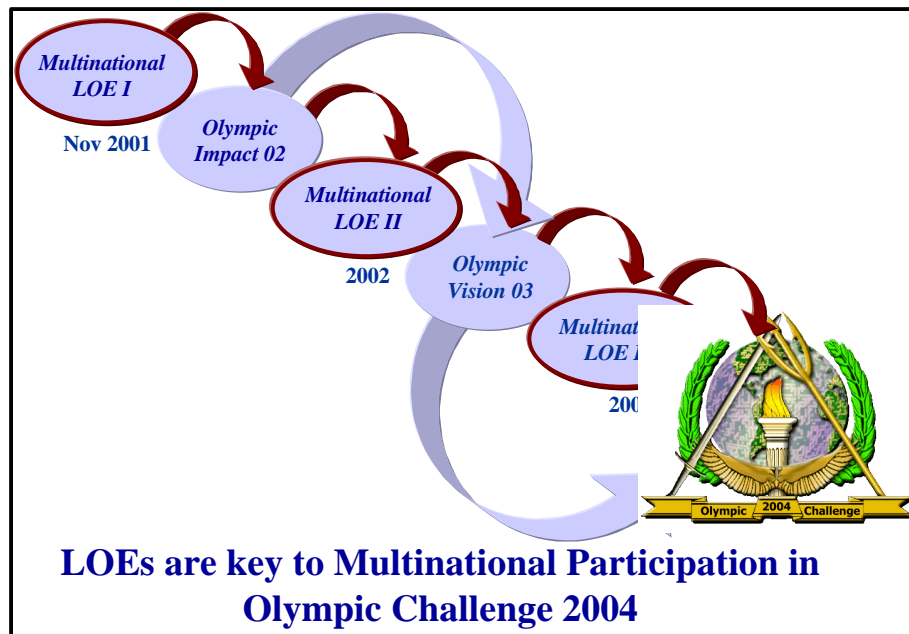

Figure 7: The Multinational LOE Relation to Olympic Challenge 2004

The first MNOPS LOE focused on JIP by comparing an interactive planning process embodied in the JIP process with a more traditional sequential planning process. Subsequent LOE will focus on information sharing and collaboration.

3 The U.S. Joint Forces Command Experimental Campaign

Figure 8 depicts the J9 Experimental Campaign Plan. In the context of RDO it focuses along two distinct but related pathways—Millennium Pathway and Olympic Pathway. The Millennium Pathway concentrates on near-term transformation realizing the requirements to use weapons systems that are already in our arsenal or in production. The focus therefore is on how to conduct a Rapid Decisive Operation in this decade. The Olympic Pathway, in contrast, is an integrated set of experiments that will examine how the joint force can conduct RDO in the next decade. While the Millennium Pathway is centered on using today's major platforms more effectively through a greater degree of operational jointness, the Olympic Pathway will consider what capabilities we should develop and acquire as we replace today's systems over the next decade.
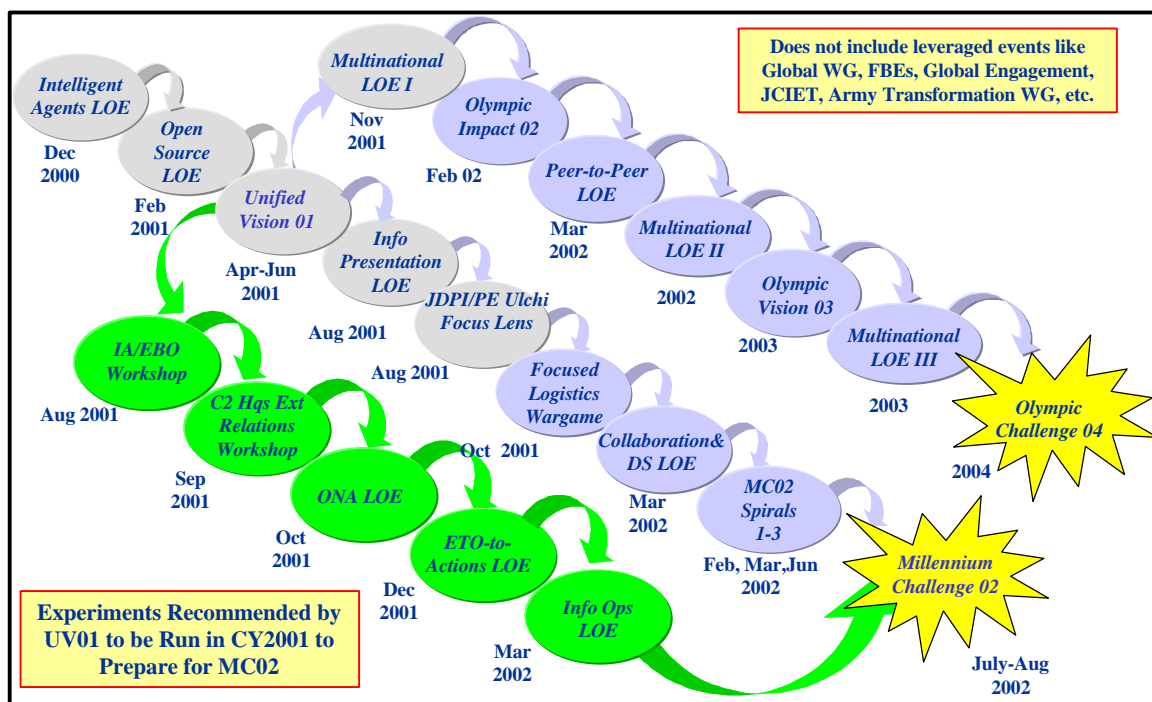

Figure 8: The J9 Experimental Campaign Plan

Both pathways will utilize series of wargames and seminars to frame issues, simulations to integrate concepts and capabilities, and live, limited objective and major experiments. However since many of the Olympic Pathway capabilities to be assessed do not yet exist, the Olympic Pathway will rely more heavily on the use of simulations, surrogates, virtual portrayals, and prototypes. Lessons learned and finding developed from the Millennium Pathway will be incorporated into the Olympic event planning and execution.

4 Experimental Assessment Methods

Experimental events prior to Unified Venture O1 (UV01) were assessed by subjective observation, participant surveys, and the traditional Army After Action Review (AAR) processes. UV01 was the first major experiment to be analyzed in detail and to assess objective data. The subjective data consisted of observations from retired General/Flag Officer Senior Concept Developers, senior members of the Interagency Community (to include two former U.S. Ambassadors), participants, and data collectors, as well as participant survey responses. Members of the JSJFCOM Joint Futures Lab analyzed the data and developed the experiment

findings. In addition quantitative data was collected and analyzed through the HEAT methodology as described below. The complete analysis is contained in the UV01 Final Report available on the USJFCOM Web site.

4.1 The Headquarters Effectiveness Assessment Tool (HEAT)

The Headquarters Effectiveness Assessment Tool (HEAT) is a joint Command and Control (C2) assessment tool that has been applied to over 250 different headquarters involved in dozens of exercises, experiments, and real world operations. By defining the C2 system as an adaptive control system and separating C2 measures of effectiveness (MOE) from the supporting measures of performance (MOP), HEAT has proven to provide a robust capacity to both understand the quality of C2 processes and to diagnose the sources of C2 problems so they can be addressed effectively. Figure 9 illustrates the HEAT Cycle.
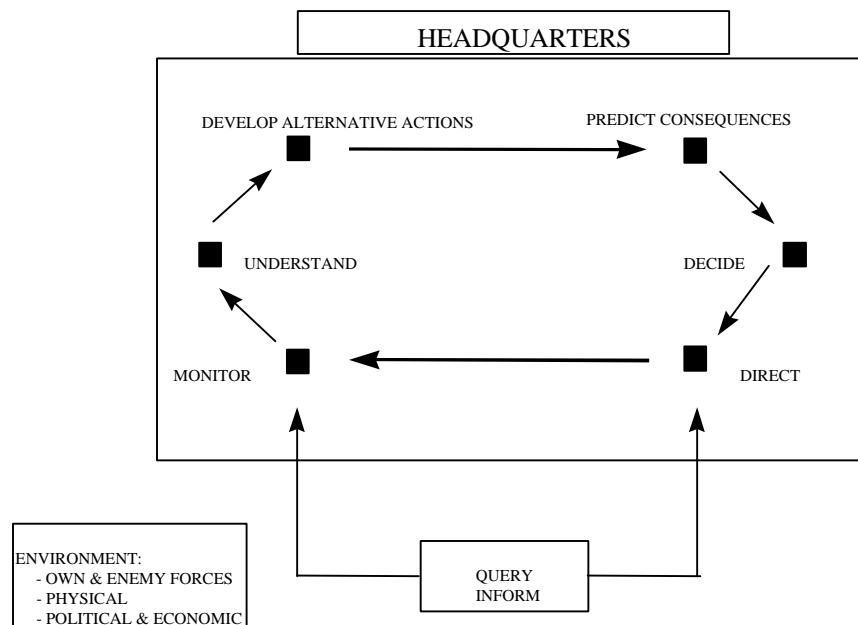

Figure 9: The HEAT Analytic Structure

A headquarters operates in a complex environment that includes among other things, own and adversary forces, the physical environment, and all other relevant factors and players. By monitoring the environment, headquarters staffs achieve situational understanding from which they can develop courses of action (COA) and predict the consequences of these COA. The Commander then chooses a course of action and issues a directive, which in turn causes an effect on the environment that the headquarters monitors. While this description implies a cyclical operation, the impact of information technologies and collaboration tools enables many of the steps to be developed in parallel rather than sequentially.

HEAT metrics can be taken at any point in the cycle and, also measure the degree and effectiveness of collaboration. For example, in an experiment or exercise where there is an established ground truth known about the environment, HEAT can measure the quality of the monitoring process as a percent of ground truth (e.g., just how accurate is the headquarters' displays of own and enemy forces). In a similar vein, HEAT can measure the accuracy and quality of the understandings that the staff and commander derive from the monitoring (e.g., "the enemy is preparing to attack").

Because of the structure of the UV 01 experiment, HEAT metrics were not applicable at every point in the cycle. This was primarily due to daily scenario time jumps, and the fact that much of the experiment was heavily scripted to support experiment objectives (e.g., development of the Operation Net Assessment (ONA) and Effects Tasking Order (ETO). Accordingly the HEAT team focused analyses on understanding quality,

decision cycle times, and collaboration effectiveness. The hypothesis was that: "A richly connected JTF Staff will develop and maintain high quality situational awareness (SA)." The metrics to support this hypothesis would be strong scores for understanding quality and frequent statements of "understandings."

4.2   Results: Understandings

An "understanding" is a situation assessment which can be thought of as a hypothesis or set of hypotheses dealing with past, current and future situations. These are scored as Correct (actual situation matches primary hypothesis), Not Incorrect (actual situation is included in contingencies), or Incorrect (actual situation is not considered). Figure 10 summarizes the results of 91 "understandings" observed, recorded, and scored in the experiment.
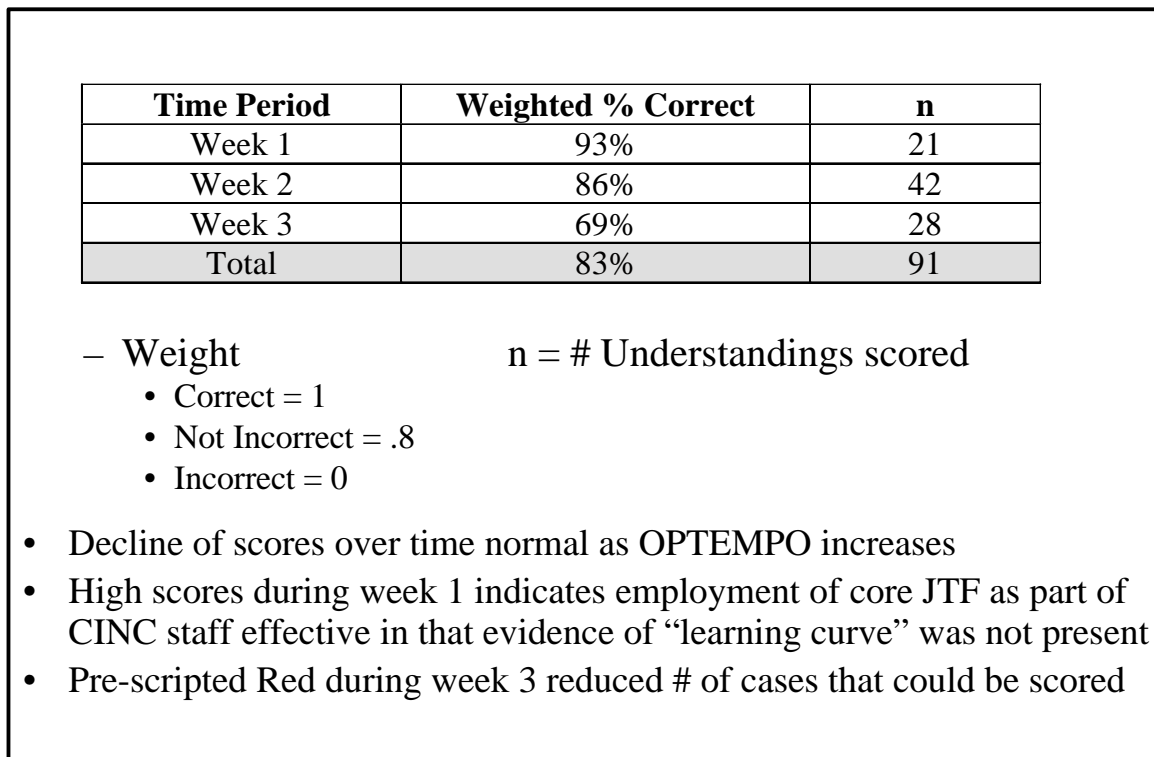
Time Period	Weighted % Correct	n
Week 1	93%	21
Week 2	86%	42
Week 3	69%	28
Total	83%	91

- Weight   n = # Understandings scored
  - Correct = 1
  - Not Incorrect = .8
  - Incorrect = 0
- Decline of scores over time normal as OPTEMPO increases
- High scores during week 1 indicates employment of core JTF as part of CINC staff effective in that evidence of "learning curve" was not present
- Pre-scripted Red during week 3 reduced # of cases that could be scored

Figure 10: Understanding Quality

The high percentage for weighted correct scores in Weeks 1 and 2 indicate that the standing JFHQ resident within the CINC staff promotes early effectiveness and significantly reduces the "learning curve" usually associated with a newly formed JTF. The decline noted during week 3 can be attributed to the increased OPTEMPO (3 separate execution vignettes) plus the fact that the execution events were all pre-scripted and played out in simulation. The primary focus of the staff during this period was to update the ETO. There was little focus placed on the actual, scripted execution.

The "understandings" results tabulated above, while useful in themselves are much more relevant when compared to a baseline. There were no direct baselines for this particular new innovative concept. However, since these comparisons are important and provide great value for data interpretation, the HEAT team utilized the deep store of previous HEAT data and derived two "Surrogate Baselines." These are presented in Figure 11.

Quality of Situational Awareness							
Surrogate Baselines	**Day 1**	**2**	**3**	**4**	**5**	**Overall**	
Joint Command Exercise in the 1980s [1]	.52	.62	.52	.60	.65	.60	Median % Correct
US Army Divisions circa 1990 [2]	.74	.82	.84	.82	.82	.81	Average % Correct

UV01	Week 1	Week 2	Week 3	Overall	Weighted % Correct
	.93	.86	.69	.83	

Interpretation:
- UV01 appears to have achieved higher understanding quality than surrogate baselines
- Unlike the Surrogates, understanding quality in UV01 declines over time
  - Time pressure is greater in later stages of UV01
  - Goal for future experimentation should be stable high % correct
  - UV01 understandings cover full range of PMESI; Surrogates focused on military issues

1 - "HEAT and the Warrior Preparation Center", Defense Systems Inc., August 1985
2 - "Use of ACCES and JESS data to Support Analyses of the Relationship of Command Staff Performance and Battle Outcomes", Defense Systems Inc., July 1988.

Figure 11. Surrogate Understandings Baseline

Two surrogate baselines were examined. The first was developed from Joint Command and Control Exercises conducted by various staffs in the 1980s. These were conducted over 5-day periods and show strong evidence of the "learning curve" effect. The second surrogate was derived from 10 Army Division level field exercises and shows a less pronounced learning curve and a significantly higher level of understanding quality. When experiment data are compared to these surrogates, an even higher level of understanding quality is noted, particularly during Weeks 1 and 2. The relevance of the Week 3 scores is viewed as qualitatively different than those for Weeks 1 and 2, because of the shift from effects based planning to the three separate execution events. In any case, the data support higher understanding quality in the experiment. It is also important to note that the surrogate baselines focused only on military issues while experiment understandings covered the full range of PMESI (political, military, economic, social, infrastructure) as shown in Figure 12. The data also point out that a goal for future experiments should be a stable high percentage of correct understandings to support Effects Based Operations (EBO).

PMESI Count - Percentage of Understandings for each category / % Correct						
Time Period	**P**	**M**	**E**	**S**	**I**	**n**
Week 1	41% / .83	49% / .98	8% / 1.0	2% / -	0% / -	49
Week 2	32% / .88	53% / .84	7% / .80	3% / -	5% / -	81
Week 3	21% / .33	71% / .74	4% / -	4% / -	0% / -	48
Total	**32% / .79**	**55% / .84**	**7% / .90**	**3% / -**	**2% / -**	**178**

n = total number of Understandings recorded

"-" = none scored

- Large increase in percentage of military during execution (Week 3) phase
- Few understandings expressed regarding economic, social and infrastructure
- Increasing military percentage over time trades off with percentage correct over time
- Focus on military understandings suggests the presence of "tunnel vision" which would threaten PMESI analyses and Effects Based Operations

Figure 12. Understandings Across the PMESI Effects

UV-01 explored new ground by its integrated focus on the effects of the total range of U.S. national power across the continuum of peacetime environmental shaping efforts, to disaster relief, to a small-scale military contingency. A large number (178) of understandings were achieved across the PMESI domains. Many of these understandings could not be scored (e.g., correct, not-incorrect, incorrect) because of the scripted nature of the experiment and the scenario time jumps. The data also show that the participants' focus was primarily on the military and political domains. As the scenario developed the "tunnel vision" phenomenon was observed as the participants focused more and more on military action, particularly in Week 3. This explains in good measure the low number of understandings in the economic, social and infrastructure domains. Nevertheless, successful EBO require a continuing focus on PMESI at the operational and strategic levels. This indicates a need to develop tools that will help the participants maintain focus across the PMESI spectrum and avoid tunnel vision.

Percentage of Understandings that considered past,
present and future situations

Time Period	Past	Present	Future
Week 1	4%	54%	42%
Week 2	3%	48%	49%
Week 3	5%	53%	42%

- Less than half of Understandings considered the future
- Not ideal to support planning or Effects Based Operations

Time Horizon - amount of time considered in future Understandings
  - Example: "After today, Red capability to deploy TBMs will be reduced" (24 hours)

- Mean future time horizon: 2.3 Days (game time)
- Median future time horizon: 2 Days (game time)

Conclusion: These time horizons are more appropriate for the tactical than the operational level

Figure 13: Understanding Time Horizons

4.3   Time Horizons/Decision Cycle Times

Understanding time horizons are important because they indicate how far into the future the staff is projecting the implications of its planning and directives, as well as the possible impact of what is already past. In the experiment less than half of the understandings considered the impact of that understanding on future operations. The median future time horizon of only 2 days recorded in the experiment is more appropriate to the tactical level and much less so to the operational and strategic levels, and definitely not ideal to support EBO planning.

	Average Cycle Time (hours)	Median Cycle Time (hours)	n
Week 1	29	21.5/24.5	6
Week 2	27.5	23.5	3
Week 3	21	23	7
Overall	25.1	23/23.5	16

- Cycle times above represent real time
- Cycle times based on game time have little meaning due to time jumps between game days
- Doesn't account for events occurring during jumps
- Doesn't factor in overnight dead time

Conclusion: The Decision Cycle Times were stable across the experiment rather than shorter during the execution phase

Figure 14: Decision Cycle Times

Decision cycle times are important indicators of staff efficiency, connectivity, and collaboration. The average and median times listed in Figure 14 tend to be artificially long because of the scripted game time jumps, and the overnight dead time. Nevertheless, the experiment cycle trends provide useful insights. While the average cycle times showed an expected compression, the median times did not, indicating that the cycle times were essentially stable across the experiment rather than shorter during execution events. Some cycle times were particularly long. Examples of long cycle times are provided in Figure 15.

- **Decision**
  - Required TMD defense of Green. First indication at 261545Feb, second when Green demands Patriots (171309Mar), TMD COA developed 011120Apr. Total 34 days (Game), 68 1/2 hours (Real)
- **Understanding**
  - At 010900APR (14 May-Real) CJTF states need to understand relationship between Red government and JTF-S. At 030900May (21 May-Real) relationship still not clear. Total 32 days (Game), 7 days (Real)
- Cycle times possibly could have been shortened had State been represented during initial planning sessions when these items were discussed

Figure 15: Long Decision Cycle Times

These long decision cycle times are symptomatic of the need to enhance the participation of State and other relevant agencies in the experiment. The interagency process in effects based operations at the operational

level is an evolving process and the experiment clearly demonstrated that there is much to learn if we are to fully exploit EBO in the context of Rapid Decisive Operations (RDO).

4.4   Collaboration

A rich collaboration environment is essential to support the RDO and EBO concepts. During the experiment there were 188 collaboration sessions documented. However, not every data element of each session was captured on the data collection sheets. This resulted in differing frequencies of responses/results for methods, tools used, and purposes of collaboration session. For example, data regarding collaboration purpose was recorded for 116 out of a total of 188 collaboration sessions because of incomplete information on the data collection forms. This was not because of data collection errors or omissions, but rather because the specific information (collaboration purpose in this example) was either not explicit or obvious, and the data collectors were trained to be unobtrusive to not interfere with the experiment.

The collaboration summaries shown in Figures 16 and 17 show interesting trends. The large amount of face-to-face collaboration in Weeks 1 and 2 as illustrated in Figure 16 is attributed to two key facts. First, the DCTS (Defense Collaborative Tool Set) was fragile and its capabilities built slowly over the first two weeks of the experiment. Second, as the participants' became more comfortable and familiar with the on-line tools, they found ways to use them more effectively (learning curve and cultural bias shift).

Method	Week 1	Week 2	Week 3
Face to Face	23 (50%)*	24 (57.1%)*	18 (32.7%)
On-Line	23 (50%)*	18 (42.8%)	37 (67.2%)*
Tools**			
Whiteboard	3 (10.3%)	5 (25.0%)	2 (4.8%)
File Sharing	13 (44.8%)*	13 (65.0%)*	3 (7.3%)
Chat	1 (3.0%)	0	8 (19.5%)
IVOX	Not Avail.	Not Avail.	12 (19.7%)*
E-Mail	0	0	5 (12.2%)
VTC	1 (3.0%)	2 (10.0%)	1 (2.4%)
Other	11 (37.9%)	0	10 (24.4%)
Not Recorded	22	24	20

- Frequency of face-to-face was consistent over first 2 weeks then declined in third week as online interactions increased

* Indicates most frequently occurring activities & tools used
** Reported collaboration sessions only

Figure 16: Collaboration Summary of Events (1 of 2)

	Week 1	Week 2	Week 3	Total
Collaboration Purpose				
Decision Making	1 (2.6%)	0	3 (6.1%)	4
Situation Awareness	5 (13.2%)	9 (31.0%)	16 (32.6%)*	30
Planning	28 (73.7%)*	19 (65.5%)*	22 (44.9%)*	69
Other	4 (10.5%)	1 (3.4%)	8 (16.3%)	13
Problems Reported				
Procedure	0	0	3 (23.1%)	3
Training	1 (16.7%)	0	0	1
System	4 (66.7%)	4 (80.01%)	10 (76.9%)	18
Personal	0	1 (20.0%)	0	1
Other	1 (16.7%)	0	0	1

- Planning Collaboration was most frequent, with SA 2nd most common
- Planning Collaboration Activities decreased over time, as Situation Awareness Collaboration Activities increased over time
- Observers did not focus on or report many problems; most were system problems

  * indicates most frequently occurring activities

Figure 17: Collaboration Summary of Events (2 of 2)

Collaboration was most utilized during planning and for situational awareness. As the experiment focus shifted to execution during Week 3, situational awareness collaboration increased significantly. Problems reported with collaboration were mostly associated with the DCTS system, however the learning curve evidence also indicates that more, up-front training would have been valuable. Figure 18 shows some examples of how collaboration made significant differences for both planning and execution, and offers the insight that the collaborative environment is essential for rapid planning and execution.

Week 1 - COA #2 chosen by CINC within 23 minutes of COA alternatives being developed. Short cycle time possible because CINC represented in COA development process.

Week 3 - CINC disapproval of use of C-117s in assault operations. This became known to planners during ETO 1C development, enabling work-around using "chat" feature to be constructed during planning process—CINC was represented during planning collaboration process.

Week 3 - CINC representative notices that CPCM sites not incorporated in ETO 1B during planning.

Week 3 - Dynamic retasking of ISR assets to identify hostile intent of swarming boats accomplished in 15 minutes as a result of collaboration between SOF OPS, CINC JIC, JTG OPS Director, JSOTF.

Figure 18: Collaboration Helped Examples

4.5   Summary

The hypothesis that "A richly connected JTF Staff will develop and maintain high quality situation awareness," was supported. When compared to surrogate baselines of both command post (CPX) and field (FTX) exercises, the experiment understanding quality was clearly better. This enhanced quality is particularly relevant given the experiment scripting and time jumps, which would tend to reduce understanding quality because of the lack of situational continuity. The absence of the learning curve effect is a strong indication that the core SJFHQ concept is on the right track.

The collaborative environment and resulting collaboration are the links that provided the "rich staff connection." As the collaboration tools became more robust over the course of the experiment, and the JTF staff became more adept with the tools and more comfortable working in the collaboration environment, planning errors and decision cycle times were reduced. Collaborative planning started immediately while situational awareness collaboration developed over time. Further training and experience with the collaboration tools should further improve collaboration.

While the empirical data indicate that the time horizon was short of ideal, this may well be an artifact of the experimental design. Extensive, heavy scripting and time jumps caused the participants to be faced with a new situation every day. Under these conditions, it is difficult to achieve and maintain coherent time horizon continuity.

Likewise, the long decision cycle times observed were attributed to both the experiment design and the need for greater and better-integrated interagency involvement in the experiment. Effects Based Operations cannot achieve their potential through military actions alone. There must be strong linkage and involvement by the other relevant actors to maintain the effects focus and to avoid tunnel vision. Future experiments should emphasize interagency involvement in the EBO process.

5   The Road Ahead

While the terrorist attacks of September 11, 2001 have caused increased emphasis on homeland security, the U.S. Joint Forces Command is still fully committed to the transformation of the U.S. Armed Forces through Joint Experimentation. The Experimental Campaign Plan may receive some fine-tuning, however the basic goals and milestones will go forward as planned. Quantitative analysis utilizing HEAT will remain an integral part of the assessment methodology.

Author Biography

Rear Admiral Gary Wheatley USN (Ret.) is a Program Manager at Evidence Based Research, Inc. He is a former Navy Pilot and Aircraft Carrier Commanding Officer. Since leaving active duty he has specialized in advanced technologies and command and control research.